

Title: Pump

This application claims priority to United Kingdom Patent Application No. 0223516.6 filed October 10, 2002, the entire disclosure of which is incorporated herein by reference.

Field of the Invention

The present invention relates to a pump, particularly, but not exclusively for use in pumping lubricant such as oil into an engine.

Description of the Prior Art

Conventionally, a positive displacement pump such as a gear pump or gerotor is used to pump a liquid lubricant such as oil in an engine. When the engine is cold, on start-up for example, the oil is relatively viscous, and pumping oil of such high viscosity with a conventional positive displacement pump is not only inefficient, but when the pump is electrically driven, this can put the pump motor under undesirable strain.

Summary of the Invention

According to a first aspect of the invention we provide a pump including a driving part and a pumping part, the pumping part including a plurality of generally parallel planar elements mounted for rotation about a first axis, wherein the driving part is coupled to the pumping part by means of a magnetic coupling device such that rotation of the driving part causes rotation of the pumping part about the first axis.

A pump in which liquid to be pumped is moved by a plurality of generally parallel planar elements such as discs or annular plates will hereinafter be referred to as a disc pump. An advantage of a disc pump is that the efficiency of such a pump is greater when the viscosity of the pumped liquid is greater. Thus, a disc pump most advantageously may be used in the invention to pump high viscosity liquid such as cold oil.

Moreover, by virtue of coupling the driving part to the pumping part by means of a magnetic coupling device, slip may occur between the driving part and pumping part if the torque necessary to rotate the pumping part exceeds a threshold value.

Thus, where the driving part is motor driven, the possibility of the motor being damaged as a result of it being placed under strain when pumping high viscosity liquid is reduced.

Preferably, the magnetic coupling includes a first coupling part which is connected to the driving part for rotation with the driving part, and a second coupling part which is connected to the pumping part for rotation with the pumping part, one of the first or second parts including a magnet, and the other of the first or second parts including an electrically conductive part.

Preferably the first coupling part and second coupling part are mounted for rotation about the first axis.

Preferably, the magnet is a permanent magnet.

The magnet may have a side wall which encloses a generally cylindrical space, and the electrically conductive part may be generally cylindrical and may be located at least partly within the wall of the magnet.

The electrically conductive part of the magnetic coupling may include a plurality of elongate copper elements arranged in a generally circular array around an axis of rotation of the first part of the magnetic coupling, a longitudinal axis of each copper element being generally parallel to the axis of rotation. The electrically conductive part may also include two generally annular copper plates which are mounted on either side of the copper elements in contact with end portions of all the copper elements. The electrically conductive part may also include a soft iron core.

Preferably the second coupling part is, in use, immersed in the liquid to be pumped, and a sealing part is provided between the first and second coupling parts, the sealing part substantially preventing pumped liquid from contacting the first coupling part and the motor.

Preferably the pumping part includes a plurality of generally parallel, co-axial discs.

According to a second aspect of the invention we provide an engine including a lubricant pump according to the first aspect of the invention.

According to a third aspect of the invention we provide a lubrication system for an engine including two lubricant pumps, one of which is a pump according to the first aspect of the invention which is adapted to pump lubricant on start-up of the engine.

By virtue of the viscosity of lubricant such as oil decreasing with increasing temperature, the pump of the invention lends itself particularly for use pumping lubricant in an engine. Whereas the efficiency of the disc pump decreases as temperature rises to a usual working temperature, the amount of slip of the magnetic coupling alone will decrease as less torque is imposed on the driving part.

Description of the Drawings

The invention will now be described with reference to the accompanying drawings of which,

FIGURE 1 illustrates a cross-section through a pump according to the invention, and

FIGURE 2 illustrates an exploded perspective view of the magnetic coupling and sealing part of the pump of figure 1,

FIGURE 3 is a schematic illustration of a lubrication system according to the third aspect of the invention.

Description of the Preferred Embodiments of the Invention

Referring to the figures, there is shown a pump 10, typically for use in pumping lubricating oil in an automotive engine. The pump 10 includes a driving part 12, which in this case is the output shaft 12 of an electric motor 18, and a pumping part 14, hereinafter referred to as a disc pack 14, the disc pack 14 including a plurality of co-axial, generally parallel discs 16. Typically, the motor 18 is an electric motor, but any other type of motor 18 may be used. The output shaft 12 of the motor 18 is coupled to the disc pack 14 by means of a magnetic coupling 20.

The magnetic coupling 20 includes a first coupling part 22 which is connected to the motor output shaft 12 and which is mounted for rotation with the output shaft 18 about an axis A, and a second coupling part 24 which is connected to the disc pack 14 and mounted for rotation with the disc pack 14.

The first coupling part 22 includes a magnet 26, in this case a permanent magnet, with a circular base 26a and a side wall 26b which encloses a generally cylindrical space. The motor output shaft 12 is connected to the base 26a generally at the centre of the base 26a such that the side wall 26b extends axially away from and generally parallel to the output shaft 18.

The second coupling part 24 is generally cylindrical and includes an electrically conductive part with plurality of copper bars 28a arranged in a generally circular array around the axis of rotation A. The bars are spaced from one another with a longitudinal axis of each of the bars 28a parallel to the axis of rotation A. The copper bars 28a are mounted between two annular copper plates 28b such that both ends of each copper bar 28a are in contact with a copper plate 28b. The copper plates 28b are normal to and centred around the axis of rotation A, and provide an electrical connection between the copper bars 28a. The bars 28a and plates 28b are supported on a soft iron core 28c.

The second coupling part 24 is mounted around a cylindrical bearing shaft 30 for rotation about the bearing shaft 30. The bearing shaft 30 extends along the axis A, and the second coupling part 24 is rigidly connected to the disc pack 14 such that the second coupling part 24 and disc pack 14 may rotate together about axis A. In this example, the disc nearest the coupling 20 is bolted to the second coupling part 24, but the second coupling part 24, may alternatively be welded to the disc pack 14, or moulded as an integral part of the disc pack 14.

The motor output shaft 12 and magnetic coupling 20 are contained within a generally cylindrical housing 32 which extends from a casing 18a of the motor 18. The housing 32 has four wings 32a which extend radially outwardly from the housing 32 to which are bolted, at an end of the housing 32 opposite the motor 18, a volute 34 with an inlet port 34a and an outlet port 34b, the disc pack 14 being contained within the volute 34. The volute 34 is of a conventional spiral configuration with the inlet port 34a located generally centrally of the volute 34 and extending generally along the

axis of rotation A of the second coupling part 24 and the disc pack 14, and the outlet port 34b extending tangentially outwardly from the periphery of the volute 34.

There is also provided a sealing part 36 which has a circular base 36a, a side wall 36b enclosing a generally cylindrical space, and a lip 36c which extends outwardly from an end of the side wall 36b opposite to the base 36a. The sealing part 36 is located between the first coupling part 22 and the second coupling part 24, the base 36a being adjacent to the base 26a of the first coupling part 22. The second coupling part 24 extends into the space enclosed by the side wall 36b of the sealing part 36, and the sealing part 36 extends into the space enclosed by the side wall 26b of the first coupling part 22. Thus the side wall 26b of the first coupling part 26 encloses the second coupling part 24, but the two are separated by the sealing part 36.

The base 36a of the sealing part 36 includes a generally central recess in which the bearing shaft 30 is located. The bearing shaft 30 may also be supported at its end nearest the disc pack 14.

The lip 36c of the sealing part 36 is sandwiched between the housing 32 and the volute 34, and provides a substantially liquid tight seal between the first and second coupling parts 22, 24. The sealing part 36 is made from an electrically non-conductive material, and is typically polymeric.

In use, pumped fluid may flow from the volute 34 into part of the housing 32, and may flow around the second coupling part 24. The sealing part 36 substantially prevents the fluid from flowing around the first coupling part 22 and the motor output shaft 12, and hence pumped fluid does not come into contact with the motor 18.

The oil pump 10 operates as follows.

Activation of the motor 18 causes the motor output shaft 12 and hence the first coupling part 22 to rotate about axis A. Rotation of the magnet 26 induces eddy currents in the copper bars 28a and plates 28b of the second coupling part 24, and the eddy currents produce a magnetic field. The magnetic field produced by the eddy currents interacts with that of the magnet 26, and as a result of this interaction, the second coupling part 24 rotates with the first coupling part 22.

Rotation of the second coupling part 24 causes the disc pack 14 to rotate, and shear forces in the oil between the discs of the disc pack cause the oil to be pulled around the volute 34 and pumped out of the outlet port 34b. As transfer of rotational energy from the disc pack 16 to the oil arises due to viscous drag, the efficiency of pumping decreases with decreasing oil viscosity. Thus, the efficiency of pumping decreases as the engine warms up, and the pump is particularly useful for pumping oil when the oil is cold.

If, however, the fluid is so viscous that the torque required to rotate the disc pack 14 exceeds a threshold value, the magnetic coupling 20 will slip such that the second coupling part 24 rotates at a lower speed than the first coupling part 22. This is possible because the first coupling part 22 is not mechanically connected to the second coupling part 24. Slip may occur, for example, when pumping cold oil on engine start-up.

The threshold value of the torque before slip occurs can be determined by providing the first coupling part 22 with a magnet 26 of an appropriate strength. The stronger the magnetic field produced by the magnet 26, the higher the maximum value of torque transferred. Slip of the magnetic coupling 20 assists in protecting the motor 18 from damage through turning against excessive torque.

When the pump 10 is used for pumping lubricating oil into an automotive engine, as the engine warms up, the viscosity of the oil decreases, and hence the efficiency of the disc pack 14 in pumping the oil decreases. The torque required to rotate the disc pack 14 decreases, however, and thus slip between the first and second coupling parts 22, 24 is reduced if not eliminated. Thus as the efficiency of the disc pack 14 in pumping fluid decreases, the efficiency of the coupling 20 in transferring motive power from the motor 18 to the disc pack 16 increases.

A pump 10 according to the first aspect of invention may be used instead of a conventional oil pump in an engine such as an automotive engine, or may be used in a lubrication system as a supplementary pump to pump oil when the engine is cold. An example of such an engine lubrication system is illustrated in Figure 3, and includes a

supplementary pump 10 according to the first aspect of the invention, and a main pump 40 which is a conventional engine lubrication pump such as a positive displacement pump, both of which are adapted to pump lubricant, such as oil, from a lubricant reservoir 42 into the engine 44.

A control device 48 is also provided, the control device 48 being adapted to select which pump 10, 40 is to be used to pump lubricant into the engine 44. On engine start-up, when the engine is cold, the control device 48 is adapted to select the supplementary pump 10, and when the engine approaches its usual working temperature, the control device 48 is adapted to switch to select the main pump 40 instead of or in addition to the supplementary pump 10. The control device 48 may be adapted to switch between pumps 10, 40, or the pumps 10, 40 may operate simultaneously, for example during a transition period, as desired. The control device 48 may be adapted to control flow of power to the pumps 10, 40 and/or flow of lubricant to the pumps 10, 40.

The pump 10 need not be driven by a motor 18. It may instead be driven by means of a power take-off from the engine for which the pump is providing lubrication.